



ENERGY PHOTOVOLTAICS, INC.

EPV Reliability Update

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Overview

- New Production Facilities and Test Sites
- Status of Reliability Projects for the EPV-40 module

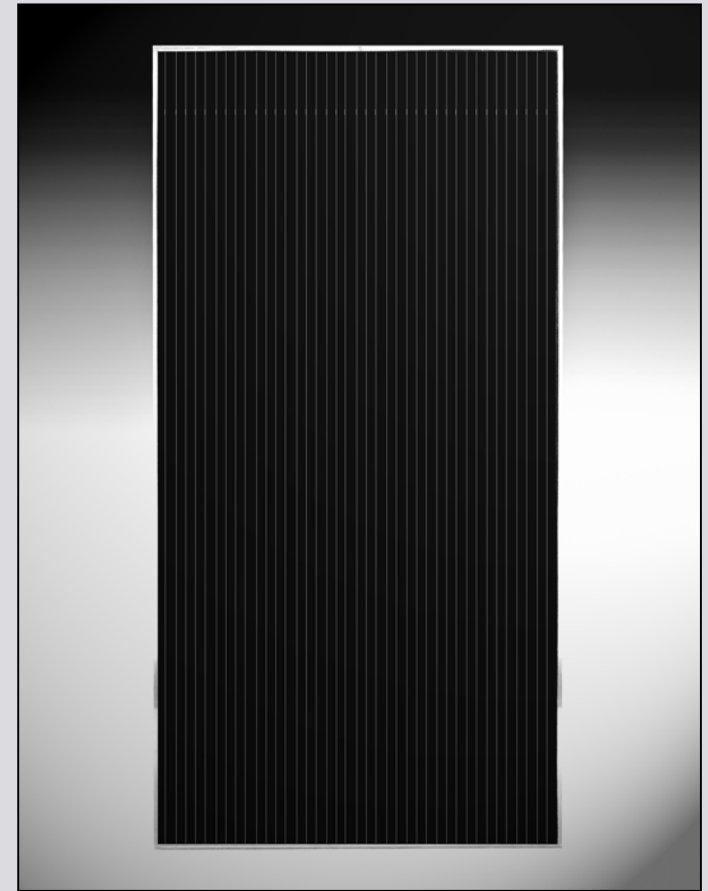
Current Project Areas:

- Breakage
 - Corrosion
 - Long Term Power Output
-
- Status of Reliability Projects for the Next Generation of EPV Modules
 - Flexible Backsheet Modules
 - CIGS Modules



The EPV- 40 Module

Rating:	40 watts (stable)
Dimensions:	25 inches x 49 inches (63.5 cm x 124.5 cm)
Weight:	27 pounds (12.3 kg)
Mounting:	a frameless module that can accommodate a variety of mounting systems
Encapsulation:	glass-EVA-glass
Technology:	a-Si/a-Si tandem



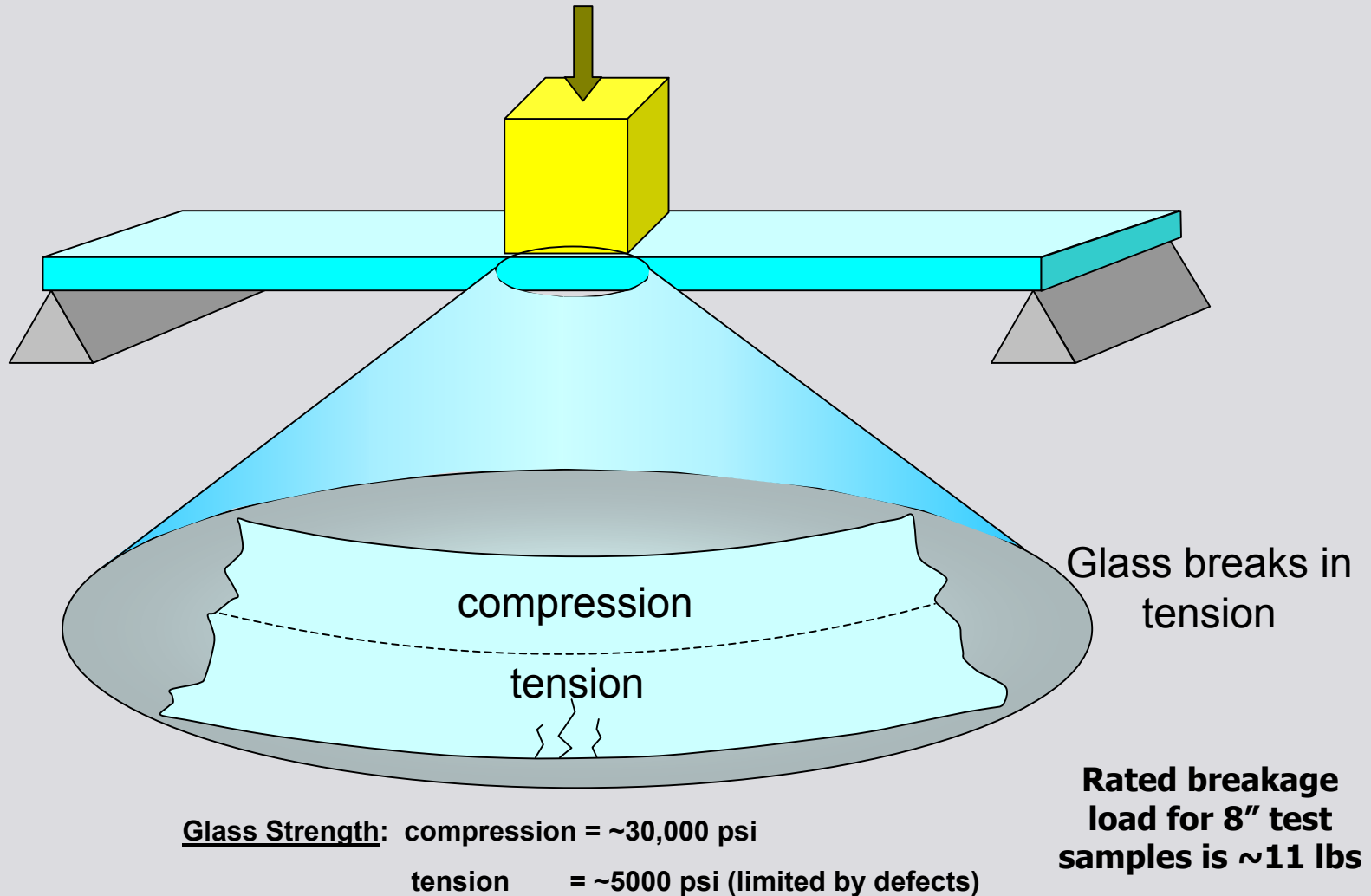
New Production Facilities and Test Sites

- **Tianjin, China**
 - 2.5 MW/yr
 - On-line and operational
- **Heliodomi – Kilkis, Greece**
 - 5 MW/yr
 - Equipment shipments underway
- **MVV – Moehlstrasse Project**
 - >100kW grid tied array
 - Prototype/test project to develop expertise in EPV systems for multiple future applications
 - Installation is underway



Reliability Projects: Breakage Testing Update

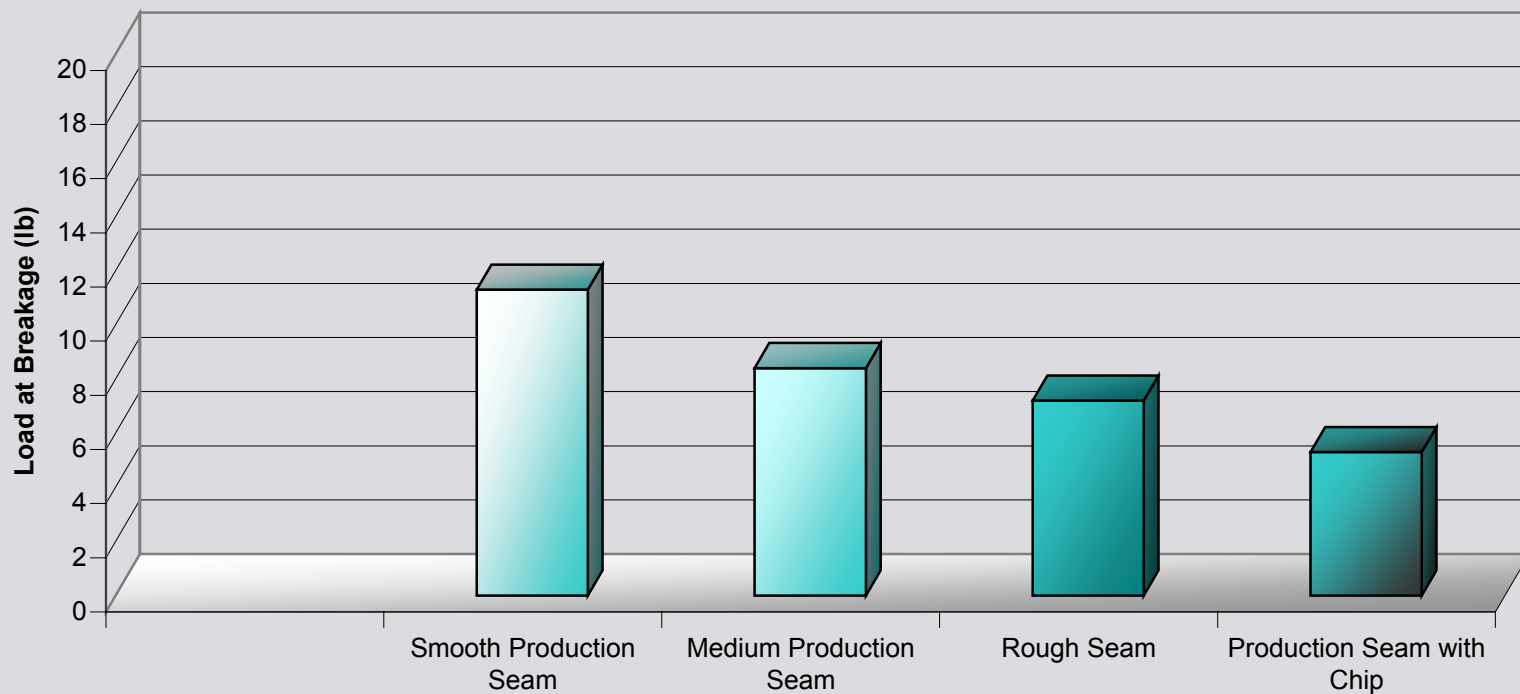
Simply Supported Beam Test Structure



Reliability Projects: Breakage Testing Update

Previous Results from Simply Supported Beam Tests

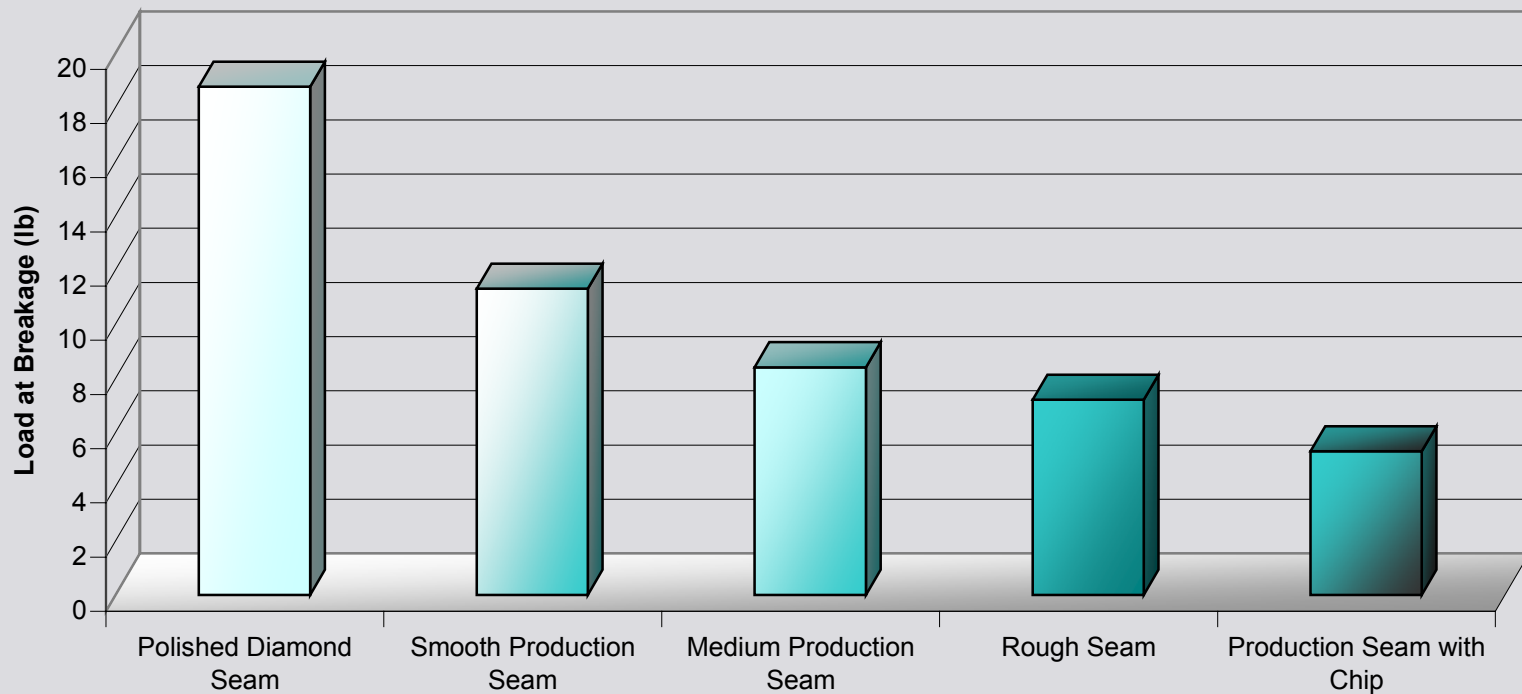
Effect of Glass Seaming on Breakage Strength



Reliability Projects: Breakage Testing Update

Updated Results from Simply Supported Beam Tests

Effect of Glass Seaming on Breakage Strength



Reliability Projects: Corrosion Testing Update

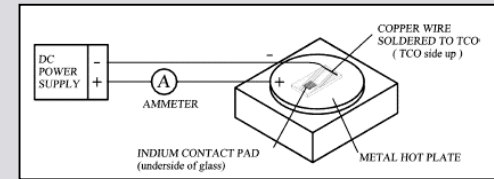
- Catastrophic corrosion failures continue to be an uncommon occurrence in EPV a-Si modules
 - Wide edge-delete region (~10 mm)
 - Effective glass-EVA-glass encapsulation
 - Frameless design for most applications
- One report of old modules showed evidence of TCO crazing on edges, but performance was found to be unaffected
 - The TCO for these modules was manufactured during the time when TCO delamination was a problem
 - As long as the encapsulation remains intact, the performance should remain unaffected, since moisture is necessary for the delamination reactions to proceed.



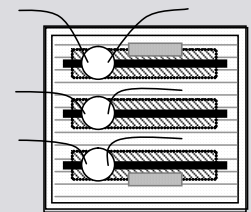
Reliability Projects:

Corrosion Testing Update

- All TCO tested in the last year has been acceptable with no delamination.
 - The adhesion problem has been effectively corrected by the glass company and we continue to monitor all incoming materials.



- Standard EPV-40 modules have successfully completed damp heat, thermal cycling, humidity freeze and other IEC 61646 tests
- Hot and humid climate study modules completed initial testing at NREL and will be deployed at FSEC shortly.
- We are collaborating with FSEC on encapsulation testing, TCO delamination, and effects of bias voltage using glass-EVA-glass and other encapsulation systems

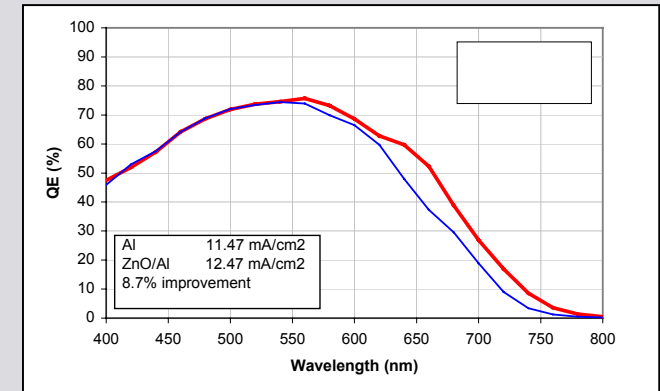


TCO test structure

Reliability Projects:

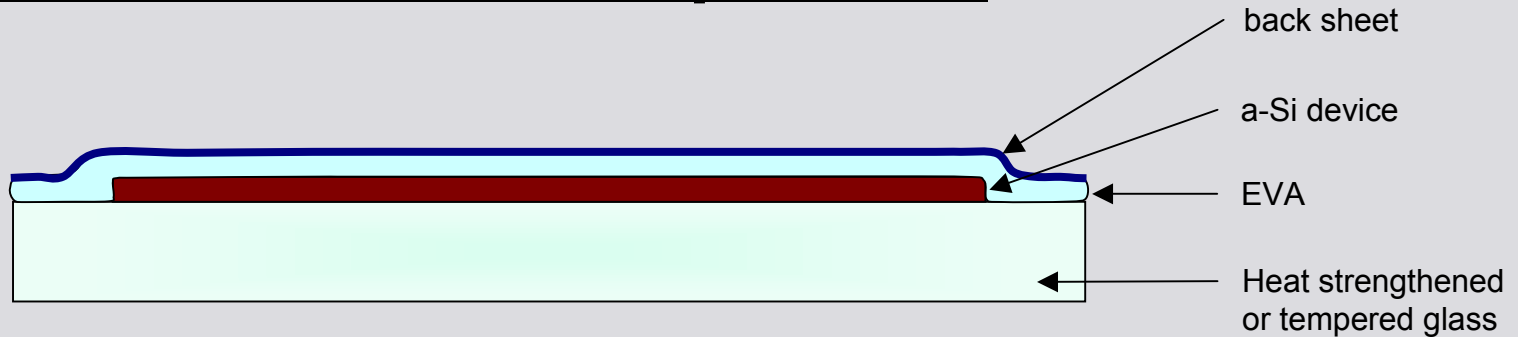
Long-Term Power Output / Stability

- Performance improvements achieved under PVMaT contract have improved performance by 15-20%
 - ZnO/Al back reflector
 - Process improvements
 - New module design to optimize active area
- Long term testing is on-going at several test sites
 - In-house
 - Laboratories (NREL, Sandia, etc.)
 - Customer sites (MVV, Heliodomí, 4 Times Square, etc.)
 - Long-term performance continues to be predictable with seasonal variations



Next Generation EPV Modules

Flexible Back Sheet Encapsulation



- Advantages:
 - modules are about half the weight of glass-EVA-glass modules
 - less labor to manufacture – no back glass fabrication
 - safer and easier processing for operators – glass handling is reduced and flexible back sheets are light and easy to handle
 - module is more resistant to breakage (when tempered glass is used)

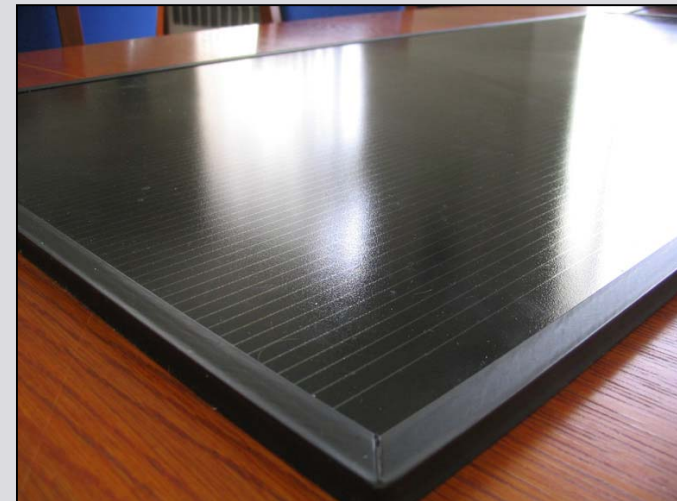
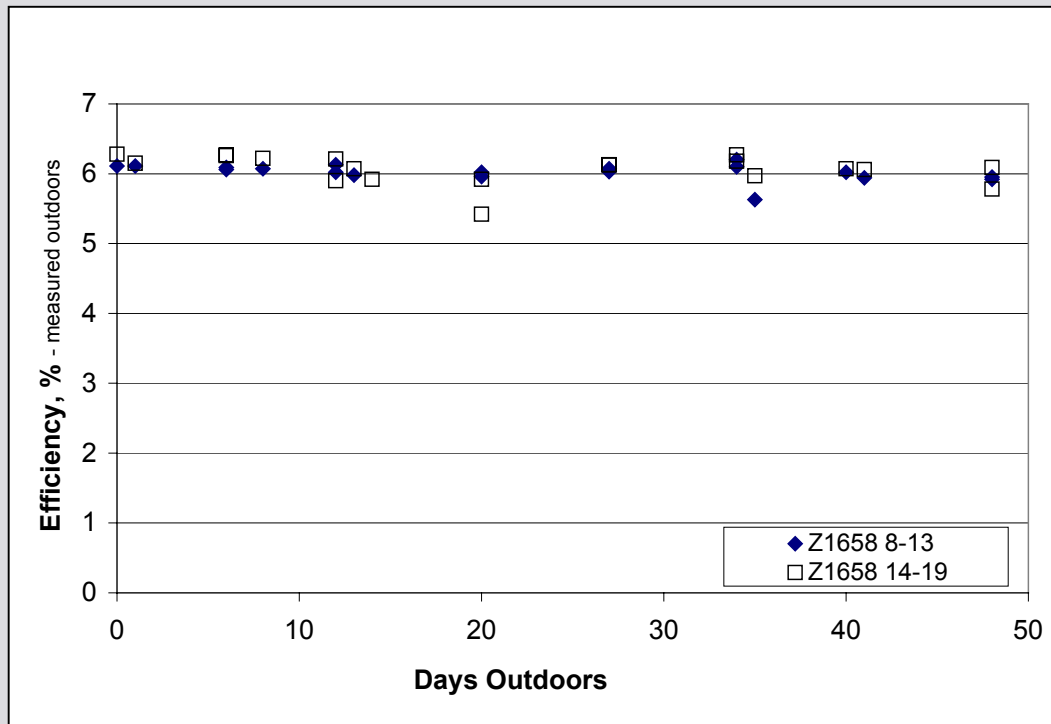
Next Generation EPV Modules

- Disadvantages
 - Cost is higher
 - currently, back sheet material costs more than glass, but this is partially offset by labor cost savings
 - TCO glass must be heat strengthened or tempered
 - Single sheet of 3 mm annealed glass will not pass load tests
 - Heat strengthening/tempering is an added cost for most applications
 - Cannot produce submodules
 - If heat strengthened or tempered glass is cut, glass strength is compromised and/or glass shatters (depending upon stress in glass)
 - Reduces production line flexibility
 - Mounting systems need to be redesigned
 - Frames/mounting systems must be modified for a thinner module
 - Pottants/adhesives need to be compatible with back sheet
 - Outdoor testing is underway for 2 back sheet candidates
 - PEN/Al/PET bonded to EVA
 - PVF/Al/PET bonded to EVA
- ✓ **Both are performing well thus far**

Next Generation EPV Modules

CIGS Module Reliability / Stability

- Initial outdoor testing of CIGS modules are encouraging
- Two 6"x17" submodules cut from full sized plates (17"x38") demonstrate stable performance over the first 48 days deployed outdoors



Future Directions

- ❑ Continue making reliability improvements on EPV-40
 - Expand failure analysis and environmental testing at NJ facility
 - utilize additional resources at NREL, Sandia, FSEC, ASU-PTL, factory sites (China and Greece), and customer sites (Germany, California, New York City, etc.)
 - Incorporate performance improvements into NJ facility modules
 - Including high performance ZnO/Al back reflector and other enhancements developed under our PV Manufacturing R&D contract
 - Re-certify EPV-40 under IEC/IEEE/UL as necessary
 - Develop low-cost mounting systems for improved module reliability
- ❑ Develop a prototype low-cost/highly reliable flexible back sheet module and evaluate cost effectiveness
- ❑ Continue long term outdoor testing and development of high performance CIGS modules